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Development of Long-Lifetime, Low-Contamination Beam Dumps for NIF

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The laser architecture of the NIF beamlines requires small-area beam dumps to safely absorb back reflections and leakage through the PEPC switch. The problem presented by these beam dumps is that the fluences they must absorb are very large. Back reflections, which come from pinholes or the system output, return to the transport spatial filter (TSF) along the direction of pass 3, after two additional passes through the multipass and booster amplifiers. Calculations show that a 1% back reflection of the 1ω output energy can produce back-reflected energies of several kilo-joules. The maximum beam area where a beam dump could be positioned without interfering with the main beam is limited to substantially less than 10 cm^2 by the 3 cm spacing between TSF pinholes in the NIF baseline. Consequently, a 1% back reflection could subject this beam dump to several hundred J/cm^2. A similar problem exists for safely absorbing leakage through the PEPC switch after pass 4 in the NIF multipass cavity. In this case, the energy returns to the cavity spatial filter (CSF), and the maximum beam area is limited to less than 1 cm^2 by the 1 cm spacing of the CSF pinholes. Current NIF specifications allow as much as 100 J to the beam dump, giving a fluence > 100 J/cm^2. For both cases, the fluences which must be absorbed are well above the damage threshold of the best optical materials, and the problem is to design beam dumps that will survive adequately and not contaminate other optics in the spatial filters.

Small-scale tests of an absorbing-glass beam dump at 200 J/cm^2 showed plasma formation and material ablation at the surface, and severe shattering of the glass several millimeters under the surface. Although the surface survived quite well for absorbing subsequent pulses, the interior damage increased with subsequent shots, leading to a complete fracturing of the glass block after a few ten's of shots. Tests on sheet stainless steel showed similar surface phenomena, but no bulk damage, raising the possibility of metal beam dumps. Small-scale tests of metal beam dumps at a fluence of 400 J/cm^2 for a thousand shots have confirmed long-term survivability

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Tests on Beamlet of a full-scale stainless-steel beam dump at up to 1.5 kJ and 450 J/cm^2 demonstrated survivability at NIF-like incident energies for at least 8 shots. Calculations indicate a shielding of the surface by the plasma generated from the leading edge of the pulse, which qualitatively explains the observed low volume of material removal. We plan additional tests of different beam dump geometries and materials with the goal of minimizing contamination from ablation.